XVIII. *Experiments and Observations on Shell and Bone.* By Charles Hatchett, *Esq. F. R. S.*

Read June 13, 1799.

SOME experiments which I lately made at the request of Mr. HOME, and which he has done me the honour to mention in his ingenious Paper on the teeth of graminivorous quadrupeds, induced me to turn my attention more particularly to the chemical examination of shell and bone, especially as the former appeared to have been hitherto much neglected.

The time since these experiments were began, has not been sufficient to enable me to enter into all the minutiæ of the chemical analysis of these substances; but, as some remarkable facts were ascertained, I have now ventured to bring them forward, with the addition of some observations, although, as yet, the whole is little more than a very imperfect outline.

The first of these experiments were made on the shells of marine animals; and, to avoid repetition and prolixity, I shall, in a great measure, once for all describe the menstrua, the precipitants, and the mode of operation.

When shells were examined, they were immersed in acetous acid, or nitric acid diluted, according to circumstances, with 4, 5, 6, or more parts of distilled water; and the solution was always made without heat.

The carbonate of lime was precipitated by carbonate of ammoniac, or of potash; and phosphate of lime (if present) was previously precipitated by pure or caustic ammoniac.

If any other phosphate, like that of soda, was suspected, it was discovered by solution of acetite of lead.

Bones and teeth were also subjected to the action of the acetous, or diluted nitric and muriatic acids.

The dissolved portion was examined by the abovementioned precipitants; and, in experiments where the quantity of the substance would permit, the phosphoric acid was also separated by nitric or sulphuric acid. The phosphoric acid thus obtained, was proved, after concentration, by experiments which, being usually employed for such purposes, are too well known to require description.

It is necessary moreover to observe, that as the substances examined were very numerous, and my principal object was to discover the most prominent characters in them, I did not, for the present, attempt in general to ascertain minutely the proportions, so much as the number and quality, of their respective ingredients.

The greater part, if not all, of marine shells, appear to be of two descriptions, in respect to the substance of which they are composed. Those which will be first noticed, have a porcellaneous aspect, with an enamelled surface, and, when broken, are often in a slight degree of a fibrous texture.

The shells of the other division have generally, if not always, a strong epidermis, under which is the shell, principally or intirely composed of the substance called *nacre* or mother of pearl.

Of the porcellaneous shells, various species of Voluta, Cypræa, and others of a similar nature, were examined.

Of the shells composed of *nacre* or mother of pearl, I selected the oyster, the river muscle, the *Haliotis Iris*, and the *Turbo olearius.*

Experiments on Porcellaneous Shells.

Shells of this description, when exposed to a red heat in a crucible, during about a quarter of an hour, crackled and lost the colours of their enamelled surface; they did not emit any apparent smoke, nor any smell like that of burned horn or cartilage. Their figure remained unchanged, excepting a few flaws; and they became of an opaque white, tinged partially with pale gray, but retained part of their original gloss.

The shells which had not been exposed to fire, (whether entire or in powder,) dissolved with great effervescence in the various acids; and the solution afterwards remained colourless and transparent.

But the shells which had been burned, upon being dissolved, deposited a very small quantity of animal coal; and thereby the presence of some gluten was denoted, although the proportion was too small to be discovered in the solution of the shells which had not been burned.

The various solutions were filtrated, and were examined by pure ammoniac and acetite of lead; but I never obtained any trace of phosphate of lime, nor of any other combination of phosphoric acid.

The carbonate of lime was afterwards precipitated by carbonate of ammoniac; and, from many experiments it appeared, that porcellaneous shells consist of carbonate of lime, cemented by a very small portion of animal gluten.

Previous to the experiments on shells composed of nacre or mother of pearl, I examined some Patellæ from Madeira.

When these were exposed to a red heat in a crucible, there was a perceptible smell, like that of horn, hair, or feathers.

The proportion of carbonic matter deposited by the subsequent solution, was more considerable than that of the shells abovementioned; and the proportion of carbonate of lime, relative to their weight, was less.

When the recent shells were immersed in very dilute nitric acid, the epidermis was separated, the whole of the carbonate of lime was dissolved, and a gelatinous substance, nearly liquid, remained; but without retaining the figure of the shell, and without any fibrous appearance.

These shells evidently, therefore, contain a larger portion of a more viscid gelatinous substance than those before mentioned; but the solution, separated from the gelatinous substance, afforded nothing but carbonate of lime.

Experiments on Shells composed of Nacre or Mother of Pearl.

When the shell of the common oyster was exposed to a red heat, the effects were the same as those observed in the Patellæ, and the solution of the unburned shell was similar, only the gelatinous part was rather of a greater consistency.

A species of the river muscle was next subjected to experiment. This, when burned in a crucible, emitted much smoke, with a strong smell of burned cartilage or horn; the shell throughout became of a dark gray, and exfoliated. By solution in the acids, a large quantity of carbonic matter was separated; and much less of carbonate of lime was obtained, from a given weight of the shell, than from those already mentioned.

Upon immersing an unburned shell in dilute nitric acid, a rapid solution and effervescence at first took place, but gradually

became less, so that the disengagement of the carbonic acid gas was to be perceived only at intervals.

At the end of two days, I found nearly the whole of the carbonate of lime dissolved; but a series of membranes, retaining the figure of the shell, remained, of which the epidermis constituted the first.

In the beginning, the carbonate of lime was readily dissolved, because the acid menstruum had an easy access; but, after this, it had more difficulty to insinuate itself between the different membranes, and of course the solution of the carbonate of lime was slower.

During the solution, the carbonic acid gas was entangled, and retained in many places between the membranes, so as to give to the whole a cellular appearance.

The *Haliotis Iris*, and the *Turbo olearius*, resembled this muscle, excepting that their membranaceous parts were more compact and dense.

These shells, when deprived by an acid menstruum of their hardening substance, or carbonate of lime, appear to be formed of various membranes, applied stratum super stratum.

Each membrane has a corresponding coat or crust of carbonate of lime; which is so situated, that it is always between every two membranes, beginning with the epidermis, and ending with the last formed internal membrane.

The animals which inhabit these stratified shells, increase their habitation by the addition of a stratum of carbonate of lime, secured by a new membrane; and, as every additional stratum exceeds in extent that which was previously formed, the shell becomes stronger in proportion as it is enlarged;

and the growth and age of the animal become denoted, by the number of the strata which concur to form the shell.

Although the *Haliotis Iris* and the *Turbo olearius* are composed of the true mother of pearl, I was induced to repeat the foregoing experiments, on some detached pieces of mother of pearl, such as are brought from China.

These experiments I need not describe, as the results were precisely the same.

I must, however, observe, that the membranaceous or cartilaginous parts of these shells, as well as of the pieces of mother of pearl, retained the exact figure of the shell, or piece, which had been immersed in the acid menstruum; and these membranaceous parts distinctly appeared to be composed of fibres placed in a parallel direction, corresponding to the configuration of the shell.

The same experiments were made on pearls; which proved to be similar in composition to the mother of pearl; and, so far as their size would enable me to discern, they appeared to be formed by concentric coats of membrane and carbonate of lime; by this structure, they much resemble the globular calcareous concretions, found at Carlsbad and other places, called Pisolithes.

The wavy appearance and irridescency of mother of pearl, and of pearl, are evidently the effect of their lamellated structure and semitransparency; in which, in some degree, they are resembled by the lamellated stone called Adularia.

When the experiments on the porcellaneous shells, and on those formed of mother of pearl are compared, it appears, that the porcellaneous shells are composed of carbonate of lime, cemented

by a very small portion of gluten; and that mother of pearl and pearl do not differ from these, except by a smaller proportion of carbonate of lime; which, instead of being simply cemented by animal gluten, is intermixed with, and serves to harden, a membranaceous or cartilaginous substance; and this substance, even when deprived of the carbonate of lime, still retains the figure of the shell.

But, between these extremes there will, probably, be found many gradations; and these we have the greater reason to expect, from the example afforded by the Patellæ, which have been lately mentioned.

Some few experiments were made on certain land shells; and, in the common garden snail I thought that I discovered some traces of phosphate of lime; but, as I did not find any in the *Helix nemoralis*, it may be doubted whether the presence of phosphate of lime should be considered as a chemical character of land shells.*

Experiments on the covering Substance of crustaceous Marine Animals.†

As I was not acquainted with any experiments by which the chemical nature of the substance which covers crustaceous marine animals had been determined, I was desirous to ascertain in what respect it was different from shell, and I began these

* Some experiments which I have lately made upon the cuttle-bone of the shops, have proved, that the term bone is here misapplied, if the presence of phosphate of lime is to be regarded as the characteristic of bone; for, this substance, in composition, is exactly similar to shell, and consists of various membranes hardened by carbonate of lime, without the smallest mixture of phosphate.

† Under this head I have included my experiments upon Echini, Star-fish, Crabs, Lobsters, &c.

experiments on three species of the Echinus, with which I had been favoured by the Right Honourable President.

I was the more inclined to begin with the Echini, because naturalists do not appear to be perfectly agreed, whether to call them testaceous or crustaceous animals.

KLEIN, who has written a work upon Echini, after having noticed the various opinions of RONDELET, RUMPHIUS, and others, determines that they are to be regarded as testaceous animals. His words are, "Sic plurimas testas marinas, in "statu naturali consideratas, cum echinodermatis potius quam "cum crustis astacorum vel cancrorum conferre licebit. Itaque "echinoderma, cum ARISTOTELE, qui echinos inter testacea qui-"bus facultas ingrediendi est reponit, nec non cum BELONIO, "ALDROVANDO, et excellentissimo SLOANIO, religiosé testam "appellamus, quam satis duram in nonnullis offendimus."*

But LINNÆUS was of the contrary opinion, as appears from his definition of the echinus. "Corpus subrotundum, *crusta* "*ossea tectum*, spinis mobilibus sæpius aspera."†

Now, as the experiments above related had proved, that the shells of marine animals were composed of carbonate of lime, without any phosphate, I thought it very possible, that the covering of the crustaceous animals might, in some respect, be different, and if so, I should thus, by chemical characters, be enabled to ascertain the class to which the Echinus was to be referred.

Of the three Echini which were examined, one had small spines; the second had large obtuse spires; and the third was of a very flat form.

* KLEIN, *Naturalis dispositio Echinodermatum, &c.* p. 10.

† *Systema Naturæ.* Edit. GMELIN, p. 3168.

Portions of these echini were separately immersed in acetous, muriatic, and diluted nitric acid, by each of which they were completely dissolved, with much effervescence; depositing, at the same time, a thin outer skin or epidermis. The transparency of the solutions was also disturbed by a portion of gluten, which remained suspended, and communicated a brownish colour to the liquors.

The solutions in acetous and diluted nitric acid were filtrated; after which, from the acetous solution of each Echinus, I obtained a precipitate of phosphate of lead, by the addition of acetite of lead; and, having thus proved the presence of phosphoric acid, I saturated the nitric solutions with pure ammoniac, by which a quantity of phosphate of lime was obtained, much inferior, however, in quantity, to the carbonate of lime, which was afterwards precipitated by carbonate of ammoniac.

The composition of the crust of the Echinus is therefore different from that of marine shells; and, by the relative proportions and nature of the ingredients, it approaches most nearly to the shells of the eggs of birds; which, in like manner, consist of carbonate, with a small proportion of phosphate of lime, cemented by gluten.

It remained now, to examine the composition of those substances which are decidedly called crustaceous; but, previous to this, some experiments were made on the Asterias or star-fish, of which I took the species commonly found on our coasts, and known by the popular name of five fingers, (Asterias rubens.)

The Asterias is thus described by LINNÆUS. "Corpus de-
"pressum, subtus sulcatum: crusta coriacea, tentaculis muri-
"cata." *

When the Asterias was immersed in the acids, a considerable

* *Systema Naturæ.* Edit. Gmelin. p. 3160.

effervescence was produced, and a thin external stratum was dissolved; after which, it remained in a perfectly coriaceous state, and complete, in respect to the original figure.

The dissolved portion, being examined by the usual precipitants, proved to be carbonate of lime, without any mixture of phosphate; but, in another species of the Asterias, which had twelve rays, (*Asterias papposa,*) I discovered a small quantity of phosphate of lime. I am therefore induced to suspect, that in the different species of the Asterias, nature makes an imperfect attempt to form shell on some, and a crustaceous coating on others; and that a series of gradations is thus formed, between the testaceous, the crustaceous, and the coriaceous marine animals.

It was now requisite to ascertain if phosphate of lime is a component part of the substance which covers the crustaceous marine or aquatic animals, such as the crab, lobster, prawn, and crayfish.

Pieces of this substance, taken from various parts of those animals, was, at different times, immersed in acetous, and in diluted nitric acid; those which had been placed in the diluted nitric acid, produced a moderate effervescence, and in a short time were found to be soft and elastic, of a yellowish-white colour, and like a cartilage which retained the original figure.

The same effects were produced by acetous acid, but in a less degree; in the latter case also, the colouring matter remained, and was soluble in alcohol.

All the solutions, both acetous and nitric, afforded carbonate and phosphate of lime, although the former was in the largest proportion.

There is reason to conclude, therefore, that phosphate of lime, mingled with the carbonate, is a chemical characteristic which

distinguishes the crustaceous from the testaceous substances; and that the principal difference in the qualities of each, when complete, is caused by the proportion of the hardening substances, relative to the gluten by which they are cemented; or by the abundance and consistency of the gelatinous, membranaceous, or cartilaginous substance, in and on which, the carbonate of lime, or the mixture of carbonate and phosphate of lime, has been secreted and deposited. Moreover, as the presence of phosphate of lime, mingled with carbonate, appears to be a chemical character of crustaceous marine animals, there is every reason to conclude that LINNÆUS did right not to place the Echini among the testaceous ones.

The presence of phosphate of lime, in the substance which covers the crustaceous marine animals, appears to denote an approximation to the nature of bone, which, not only by the experiments of Mr. GAHN, but by the united testimony of all chemists, has been proved principally to consist (as far as the ossifying substance is concerned) of phosphate of lime.

This consideration, therefore, induced me to repeat the above experiments, on the bones of various animals.

It is scarcely necessary for me to mention the usual effects of acids on bones steeped in them, as they are known to every physiologist and anatomist.

In every operation of this nature, the ossifying substance, which is principally phosphate of lime, is dissolved, and a cartilage or membrane, of the figure of the original bone, remains; so that the first origin of bones appears to be by the formation of a membrane or cartilage, of the requisite figure, which, when the subsequent secretion of the ossifying substance takes place,

is penetrated by it, and thus becomes more or less converted into the state of bone.

It is also known, that the nature of the bone is more influenced by the greater or less predominance of the membranaceous or cartilaginous part, than by any other cause. It is not, therefore, for me to add any thing to this part; and, in respect to the substance which is the cause of ossification, little also requires to be mentioned, for this (as has been already observed) is known principally to consist of phosphate of lime. I shall only, therefore, briefly mention the results of certain experiments.

The bones of fish, such as those of the salmon, mackerel, brill, and skate, afforded phosphate of lime; and the only difference was, that the bones of these fish appeared in general to contain more of the cartilaginous substance, relative to the phosphate of lime, than is commonly found in the bones of quadrupeds, *&c.*

The different bones, also, of the same fish, were various in this respect; and the bones about the head of the skate, only differed from cartilage, by containing a moderate proportion of phosphate of lime.

It is at present believed that phosphate, with some sulphate of lime, constitutes the whole of the ossifying substance; and perhaps the formation of bone from cartilage, depends only on the phosphate of lime; but, whether this is the case or not, it is fit that I should notice a third substance, which constantly occurred in the course of my experiments.

When human bones, or teeth, as well as those of quadrupeds and fish, whether recent or calcined, were exposed to the action

of acids, an effervescence, although at times but feeble, was produced. This circumstance, at first, I did not particularly notice, but the following experiments excited my attention.

After the phosphate of lime had been precipitated from the solutions of various teeth and bones, by pure ammoniac, I observed, that a second precipitate, much smaller in quantity, was obtained by the addition of carbonate of ammoniac. This second precipitate dissolved in acids, with much effervescence, during which, carbonic acid was disengaged; and selenite was formed by adding sulphuric acid. Moreover, the solution of this precipitate did not contain any phosphoric acid; nor did the liquor from which the precipitate had been separated afford any trace of it.

This precipitate was therefore carbonate of lime; but I still was not certain that it existed, as such, in the teeth and bones.

Although regular and comparative analyses of the bones of different animals have not hitherto been made, yet, by the experiments of Messrs. GAHN, SCHEELE, MACQUER, FOURCROY, BERNIARD, and the Marquis de BULLION, it has been proved, that phosphate of lime is the principal ossifying substance of bones in general, and that this is accompanied by a small proportion of some saline substances, and by sulphate of lime.

I was therefore desirous to ascertain, whether the carbonate of lime which I had obtained by the abovementioned experiments, had been produced from the sulphate of lime decomposed by the alkaline precipitant, or whether the greater part had not existed in the bones, in the state of carbonate.

Each of the solutions in nitric acid afforded a precipitate with nitrate of barytes; but the quantity of sulphuric acid thus separated, appeared by far too small to be capable of saturating the

whole of the carbonate of lime obtained from an equal quantity of the solution. To prove, therefore, the presence of the carbonic acid, and the consequent formation of carbonate of lime, portions of the various teeth and bones were immersed, at separate times, in muriatic acid; and the gas produced was received in lime water, by which it was speedily absorbed, and a proportionate quantity of carbonate of lime was obtained.

Although it appears, that the principal effects during ossification are produced by phosphate of lime, yet we here see, that not only some sulphate, but also some carbonate of lime, enters the composition of bones; and it is not a little curious to observe, that as the carbonate of lime exceeds in quantity the phosphate of lime in crustaceous marine animals, and in the egg shells of birds, so in bones it is *vice versa*. It is possible, when many accurate comparative analyses of bones have been made, that some may be found composed only of phosphate of lime; and that thus, shells containing only carbonate of lime, and bones containing only phosphate of lime, will form the two extremities of the chain.

I shall now make a few remarks on the enamel of teeth.

When a tooth coated with enamel is immersed in diluted nitric or muriatic acid, a feeble effervescence takes place, and the enamel is completely dissolved; so also is the bony part, but the cartilage of that part is left, retaining the shape of the tooth. Or, if a tooth in which the enamel is intermixed with the bony substance, is plunged in the acid, the enamel and the bony part are dissolved, in the same manner as before; that is to say, the enamel is completely taken up by the acid, while the tooth, like other bones, remains in a pulpy or cartilaginous state, having been deprived of the ossifying substance. Consequently,

those parts which were coated or penetrated by lines of enamel, are diminished, in proportion to the thickness of the enamel which has been thus dissolved; but little or no diminution is observed in the tooth.*

Mr. HUNTER has noticed this; and, speaking of enamel, says, "when soaked in a gentle acid, there appears no gristly or "fleshy part with which the earthy part had been incor-"porated."†

Now, when the difference which has been lately stated, between porcellaneous shell and mother of pearl, is considered, it is not possible to avoid the comparing of these to enamel and tooth.

When porcellaneous shell, whole or in powder, is exposed to the action of acids, it is completely dissolved, without leaving any residuum.

Enamel is also completely dissolved, in the like manner.

Porcellaneous shell and enamel, when burned, emit little or no smoke, nor scarcely any smell of burned horn, or cartilage.

Their figure, after having been exposed to fire, is not materially changed, except by cracking in some parts: their external gloss partly remains, and their colour at most becomes gray, very different from what happens to mother of pearl, or tooth. In their fracture they have a fibrous texture; and, in short, the only essential difference between them appears to be, that porcellaneous shell consists of carbonate of lime, and enamel of phosphate of lime, each being cemented by a small portion of gluten.

* I have also observed, that when raspings of enamel are put into diluted nitric or muriatic acid, they are dissolved without any apparent residuum; but, when raspings of tooth or bone are thus treated, portions of membrane or cartilage remain, corresponding to the size of the raspings.

† Natural History of the Human Teeth, page 35.

In like manner, if the effects produced by fire and acid menstrua, on shells composed of mother of pearl, and on the substance of teeth and bone, are compared, a great similarity will be found; for, when exposed to a red heat,

1st. They smoke much, and emit a smell of burned cartilage, or horn.

2dly. They become of a dark gray or black colour.

3dly. The animal coal thus formed is of difficult incineration.

4thly. They retain much of their original figure; but the membranaceous shells are subject to exfoliate.*

5thly. These substances, (pearl, mother of pearl, tooth, and bone,) when immersed in certain acids, part with their hardening or ossifying substances, and then remain in the state of membrane or cartilage.

6thly. When previously burned, and afterwards dissolved in acids, a quantity of animal coal is separated, according to the proportion of the gelatinous, membranaceous, or cartilaginous substance, and according to the duration of the red heat.

And lastly, the acid solutions of these substances, by proper precipitants, afford carbonate of lime, in the one case, and phosphate of lime principally, in the other, in a proportion relative to the membrane or cartilage with which, or on which, the one or the other had been mixed, or deposited.

As porcellaneous shell principally differs from mother of pearl, only by a relative proportion between the carbonate of lime and the gluten or membrane, in like manner, the enamel appears only to be different from tooth or bone, by being destitute of cartilage, and by being principally formed of phosphate of lime, cemented by gluten.

* This is a natural consequence, arising from their structure.

The difference, in the latter case, seems to explain why the bones and teeth of animals fed on madder become red, when, at the same time, the like colour is not communicated to the enamel; for it appears probable, that the cartilages which form the original structure of the teeth and bones, become the channels by which the tinging principle is communicated and diffused.

These comparative experiments prove, that there is a great approximation in the nature of porcellaneous shell and the enamel of teeth, and also in that of mother of pearl and bone; and, if a shell should be found composed of mother of pearl coated by the porcellaneous substance, it will resemble a tooth coated by the enamel, with the difference of carbonate being substituted for phosphate of lime.

Some experiments on cartilaginous substances (which I intended to have inserted in this Paper, but which I am prevented from doing, as they are not as yet sufficiently advanced,) have in a great measure convinced me, that membranes and cartilages (whether destined to become bones by a natural process, as in young animals, or whether they become such by morbid ossification, as often happens in those which are aged,) do not contain the ossifying substance, or phosphate of lime, as a constituent principle. I mean by this, that I believe the portion of phosphate of lime found in cartilaginous and horny substances to be simply mixed as an extraneous matter; and that, when it is absent, membrane, cartilage, and horn, are most perfect and complete.

The frequent presence of phosphate of lime in cartilaginous substances, is not a proof of its being one of their constituent principles, but only that it has become deposited and mixed with them, in proportion to the tendency they may have to

form modifications of bone; or according to their vicinity with such membranes or cartilages as are liable to such a change. If horns are examined, few I believe will be found to contain phosphate of lime in such a proportion as to be considered an essential ingredient. I would not be understood to speak here of such as stag or buck horn, for that has every chemical character of bone, with some excess of cartilage; but I allude to those in which the substance of the horn is distinctly separate from the bone, and which, like a sheath, covers a bony protuberance which issues from the os frontis of certain animals.*

Horns of this nature, such as those of the ox, the ram, and the chamois, also tortoise shell, afford, after distillation and incineration, so very small a residuum, of which only a small part is phosphate of lime, that this latter can scarcely be regarded as a necessary ingredient.

By some experiments made on 500 grains of the horn of the ox, I obtained, after a long continued heat, only 1,50 gr. of residuum; and, of this, less than half proved to be phosphate of lime.

78 grains of the horn of the chamois afforded only 0,50 of residuum; and 500 grains of tortoise shell yielded not more than 0,25 of a grain, of which, less than half was phosphate of lime.

Now it must be evident, that so very small a quantity cannot influence the nature of the substances which afforded it; and the same may be said of synovia, 480 grains of which did not yield more than one grain of phosphate of lime.

This substance is undoubtedly various in its proportions, in all these and other animal substances, arising probably from

* Nature seems here to have made an analysis or separation of horn from bone.

the age and habit of the animal which has produced them; but I believe that I may, at least, venture to place some confidence in the foregoing experiments, as several others, made since the above was written, have tended to confirm them.*

In the course of making the experiments which have been related, I examined the fossil bones of Gibraltar, as well as some glossopetræ or shark's teeth. The latter afforded phosphate and carbonate of lime; but the carbonate of lime was visibly owing principally to the matter of the calcareous strata which had inclosed these teeth, and which had insinuated itself into the cavities left by the decomposition of the original cartilaginous substance.

The bones of the Gibraltar rock also consist principally of phosphate of lime; and the cavities have been partly filled by the carbonate of lime which cements them together.

Fossil bones resemble bones which, by combustion, have been deprived of their cartilaginous part; for, they retain the figure of the original bone, without being bone in reality, as one of the most essential parts has been taken away. Now, such fossil or burned bones can no more be regarded as bone,

* These experiments were repeated on bladder, which I chose in preference to any other membrane, as not being liable to ossification, and therefore likely to contain very little or no phosphate of lime.

250 grains of dry hogs' bladder, after incineration, left a residuum the weight of which did not exceed $\frac{1}{50}$th of a grain. This was dissolved in diluted nitric acid; and, upon adding pure ammoniac, some faint traces of phosphate of lime were observed. Now, as 250 grains of bladder did not afford more than $\frac{1}{50}$th of a grain of residuum, of which only a part consisted of phosphate of lime, there is much reason to regard this experiment as an additional proof, that phosphate of lime is not an essential ingredient of membrane.

than charcoal can be considered as the vegetable of which it retains the figure and fibrous structure.

Bones which keep their figure after combustion, resemble charcoal made from vegetables replete with fibre; and cartilaginous bones which lose their shape by the same cause, may be compared to succulent plants which are reduced in bulk and shape in a similar manner.

From these last experiments, I much question if bodies consisting of phosphate of lime, like bones, have concurred materially to form strata of limestone or chalk; for, it appears to be improbable that phosphate is converted into carbonate of lime, after these bodies have become extraneous fossils.

The destruction or decomposition of the cartilaginous parts of teeth and bones in a fossil state, must have been the work of a very long period of time, unless accelerated by the action of some mineral principle; for, after having, in the usual manner, steeped in muriatic acid the os humeri of a man brought from Hythe, in Kent, and said to have been taken from a Saxon tomb, I found the remaining cartilage nearly as complete as that of a recent bone. The difficult destructibility of substances of a somewhat similar nature, appears also from the mining implements formed of horn, which are not unfrequently found in excavations of high antiquity.